

FINAL
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Magnetically Damped Furnace Bitter Magnet Coil 1

FINAL REPORT

M. D. Bird

INTRODUCTION

A magnet has been built by the National High Magnetic Field Laboratory for NASA on a cost reimbursement contract. The magnet is intended to demonstrate the technology and feasibility of building a magnet for space based crystal growth. A Bitter magnet (named after Francis Bitter, its inventor) was built consisting of four split coils electrically in series and hydraulically in parallel. The coils are housed in a steel vessel to reduce the fringe field and provide some on-axis field enhancement. The steel was nickel plated and Teflon coated to minimize interaction with the water cooling system. The magnet provides 0.14 T in a 184 mm bore with 3 kW of power.

TEST PROCEDURE AND DATA

I MASS

Maximum mass of magnet empty:	100 kg
Measured mass of magnet empty:	77 kg
Measured mass of magnet full:	79 kg
Measured by:	O'Reilly, Loffelbein
Equipment Used:	Pelouze Model 4040 400 lb Capacity Digital Scale +/- 0.2 kg

II STRUCTURAL AND MECHANICAL

	(g's)	(m/s ²)
Acceleration	13.6	133.416

SPRING FORCES

Desired Clamping force (N)	2000
Spring stiffness (N/mm)	21.3
Spring free length (mm)	7.94
Spring solid height (mm)	4.9
Max. spring displacement (mm)	3.04
Max. spring force/spring (N)	64.8
# of springs	50
Max. spring force/coil (N)	3238
Max. spring force tot (N)	12950

COIL MASSES AND G FORCES

Coil #	1	2	3	4
coil mass (kg)	7.4	9	11.2	15.2
Accel. Force (N)	987	1201	1494	2028
Total mass (kg)	42.8			
Total force (N)	5710			

HYDRAULIC FORCES

Water Pressure (MPa)	0.02
Head area (mm ²)	65182
Pressure load (N)	1304

DESIGN FORCE

Design force (N)	14254
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STAND-OFF ROD COMPRESSION

length (mm)	53
diameter of rods (mm)	5
number of rods	24
area (mm ²)	471
Stress (MPa)	30
Yield stress (MPa)	210
Safety factor	6.9

HEAD DEFLECTION: see Roark's formulas for stress and strain pg. 405

Outer radius	a (mm)	172
Inner radius	b (mm)	94
Thickness	t (mm)	7
Young's modulus	E (MPa)	2.10E+05
Poisson's ratio	nu	0.30
Bending stiffness	D	6.60E+06
	(N*mm)	
distributed load	q (MPa)	2.19E-01

C1	0.4392
C7	0.5839
C4	0.9957
L11	0.0014
L14	0.0118
L17	0.0768

simple support

Displacement at inner radius	y _b (mm)	1.64
	thet _b (rad)	0.02
	theta(rad)	0.02

clamped

Displacement at inner radius	y _b (mm)	0.11
Moment at outer radius	M _{ra} (N)	-452
Stress at outer radius	S _{ra} (MPa)	-55.4
Yield Stress	S _y (MPa)	-210
safety fator		3.79

VESSEL SHELL TENSION

vessel section (mm ²)	5404
vessel Sss (MPa)	2.64
vessel strain	1.26E-05
vessel length (mm)	218
vessel DL (mm)	0.27
yield stress (MPa)	210
safety factor	80

SCREW TENSION

screw section (mm ²)	14.2
# of screws	18
total moment at outer radius (Nmm)	-488761
moment per screw (Nmm)	-27153
moment arm (mm)	6.25
screw tension (N)	4345
proof load (N)	8230
safety factor	1.89

III MATERIAL COMPATIBILITY

A complete drawing package was sent to NASA and was approved before construction began. A package of as-built drawings is enclosed. Materials in contact with coolant consist of the following: stainless steel, nickel, Teflon, Kapton.

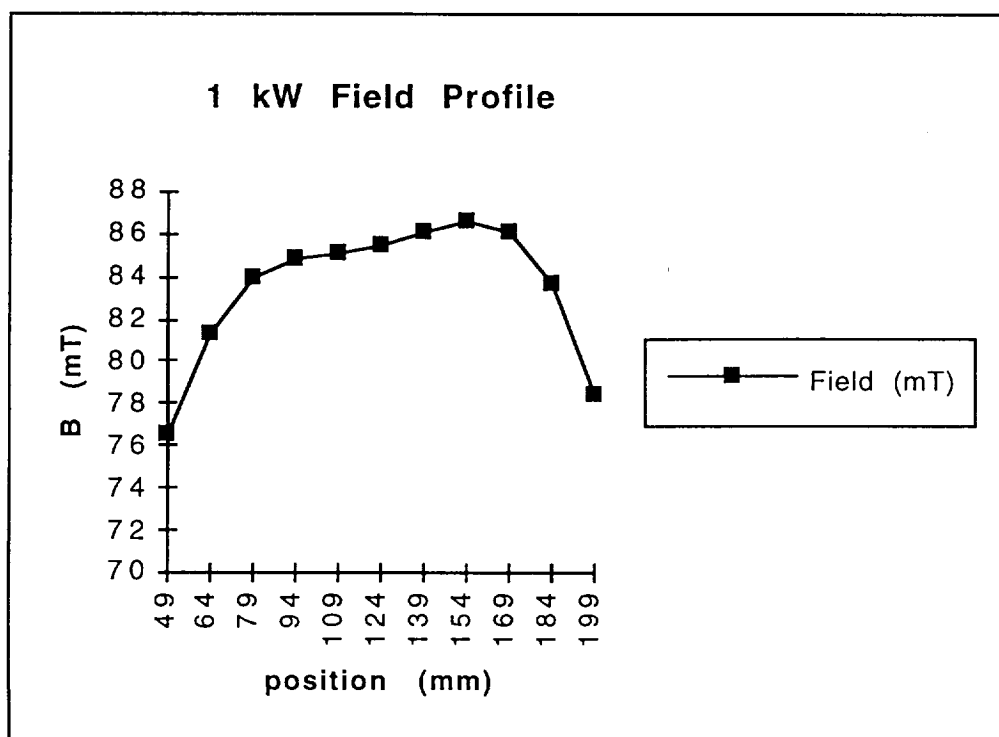
IV. DIMENSIONS

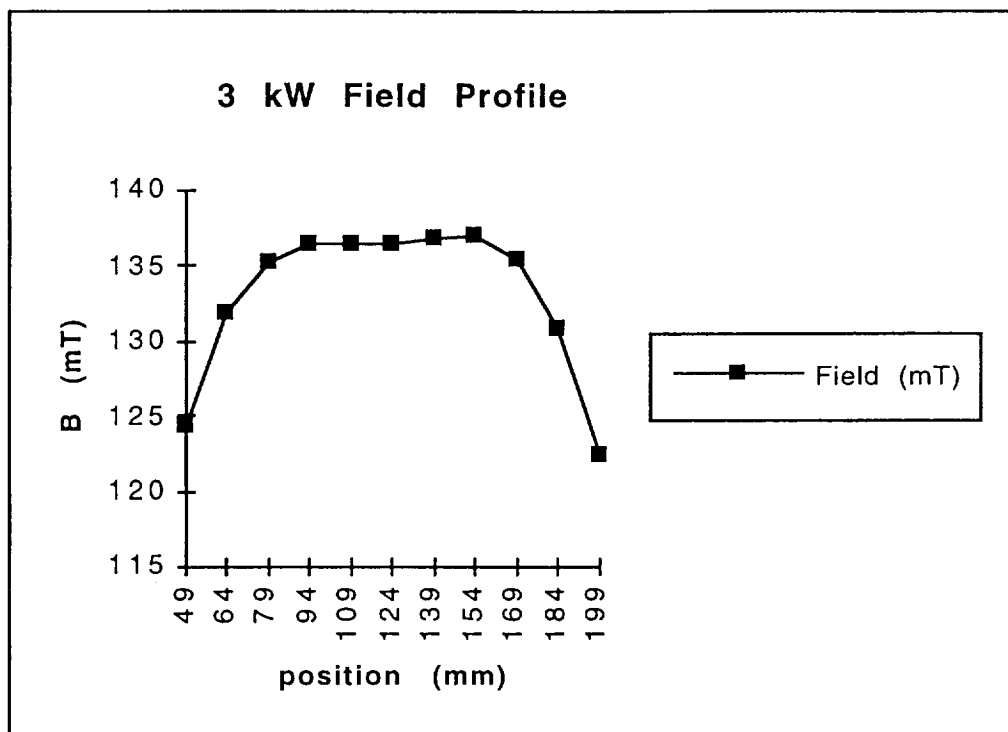
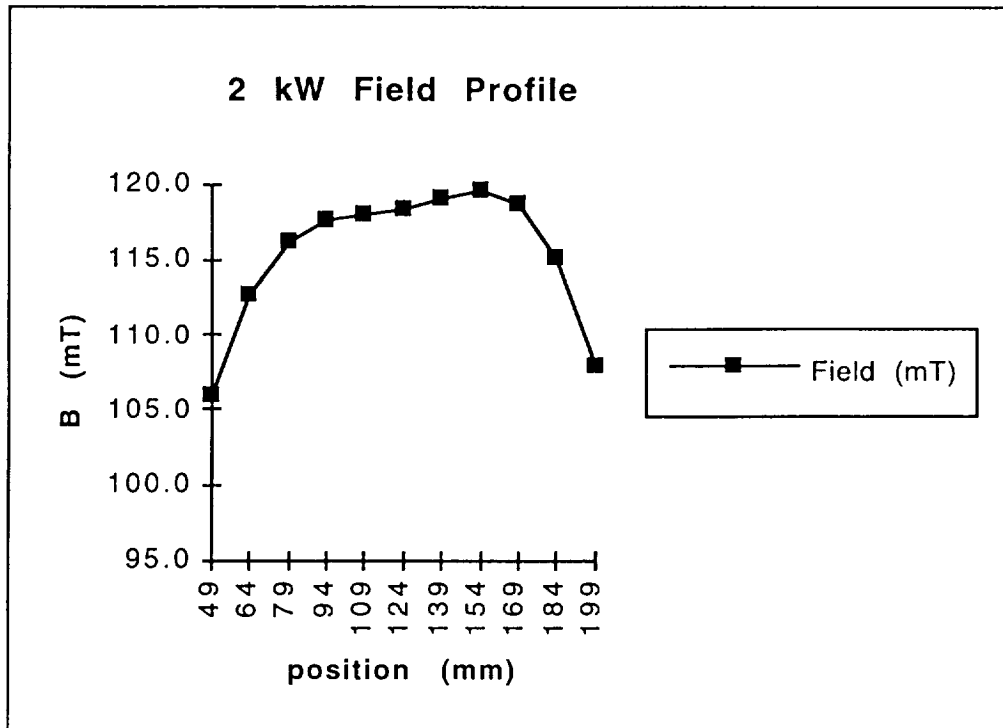
	Required	Measured
Length	238.1 mm max.	239.44, 239.58 mm
Inside diameter	184.2 mm min.	184.24, 184.26 mm
Outside diameter	361.95 mm max.	341.78, 341.42 mm
Measured by:	Bird, O'Reilly	
Equipment used:	Mitutoyo 0-55 cm caliper	

V. FIELD STRENGTH AND HOMOGENEITY

The water flow through the magnet was set at 640 ml/10 sec (230 kg/hr) as measured with a graduated cylinder and stopwatch. The current was set at 20.88, 27.87 and 31.86 Amps as measured by a shunt and multimeter. The voltage across the coil was measured at 52.28, 76.80 and 92.99 Volts for the three current settings, respectively. The electrical power consumed during the three measurements was 1092, 2140, and 2963 Watts, respectively. The field was mapped along the axis of the magnet using a Hall probe, Hall probe holder, and gaussmeter. The recorded data follows:

axial pos. (mm)	1 kW Field (mT)	2 kW Field (mT)	3 kW Field (mT)
49	76.5	105.9	124.4
64	81.3	112.6	131.8
79	83.9	116.2	135.3
94	84.8	117.6	136.5
109	85.1	118.0	136.4
124	85.5	118.4	136.4
139	86.1	119.0	136.8
154	86.6	119.5	136.9
169	86.1	118.7	135.4
184	83.7	115.2	130.9
199	78.4	107.9	122.4





Field variation over 150 mm: 1 kW = 8.2%, 2 kW = 11.4%, 3 kW = 9.1%. Specification: < 10 % at 3 kW.

Equipment used: ABB/Alpha Scientific 20kA, 500 V power supply; Weston KS9442-L6 150 A, 50 mV shunt; Keithley 2001 Multimeter (2), Lakeshore 420 Gaussmeter; Lakeshore MMA-2502-VG axial metal stem Hall probe; NHMFL RES/TOL-1 hall probe holder, Kartell, 1000 mL graduated cylinder; Fischer-Scientific Digital Dual Channel Thermometer; Micronta 63-5012 LCD electronic stopwatch

VI. POWER

See item V.

VII. ELECTRICAL ISOLATION

Required line to chassis isolation: 2 Megohms
Measured line to chassis isolation: 500 Megohms at 500 V
Equipment used: AEMC model 1000 Megohmmeter

VII. PHYSICAL POWER INTERFACE

The MDF-BC1 provides screw lug connectors capable of utilizing 8 gage wire within the zone shown in Figure 3.1.3-1 of the MDF-BC1 specifications.

VIII. COOLANT LOOP PHYSICAL CONNECTIONS

Fluid connectors are male 37 degree flare fittings size 6 per commercial equivalent of military standard 3365.

IX. INLET/OUTLET TEMPERATURE OF MDF-BC1 COOLANT

Set flow at 232 kg/hr. and measure temperature rise at 1, 2 and 3 kW.

I (Amps)	V (Volts)	T _{in} (C)	T _{out} (C)	Q (kg/hr.)
20.88	52.28	12.4	13.3	230
27.87	76.80	12.5	15.5	230
31.86	92.99	12.6	19.4	230

Performed by: Bird, Bole, Loffelbein, O'Reilly
Equipment used: see V

X. COOLANT FLOW RATE/ PRESSURE DROP

Flow (mL/10s)	Flow (kg/hr)	DP (psi)	DP (kPa)
510	184	1.2	8
610	220	1.5	10
630	227	2.0	14
700	252	2.0	14
740	266	2.3	16
830	299	2.5	17
870	313	3.0	21
900	324	3.0	21

Specification: <34.5 kPa at 232 kg/hr.
Measured by: Bird, O'Reilly
Equipment used: Wika -30 in. Hg/ +30 psi gage, 1000 mL graduated cylinder; Pulsar quartz watch.

XI. COOLANT COMPATIBILITY

A complete drawing package was sent to NASA and was approved before construction began. Materials in contact with coolant consist of the following: stainless steel, nickel, Teflon, Kapton.

Magnet water specification at the NHMFL:

Total dissolved solids (as CaCO ₃)	50 ppb
Total silica (as SiO ₂)	10 ppb
Sodium (as CaCO ₃)	40 ppb
Resistivity	6 Megohm-cm
Dissolved Oxygen	0.02 - 0.03 ppm

XII. ATMOSPHERE

The MDF-BC1 will operate in the following atmospheres:

0.1 bar Argon

18-45 degrees Centigrade air with 40 - 90 % relative humidity.

XIII. EXTERNAL FIELD

The field external to the magnet has been measured at the midplane 200 mm from the outside surface of the MDF-BC1 shielding.

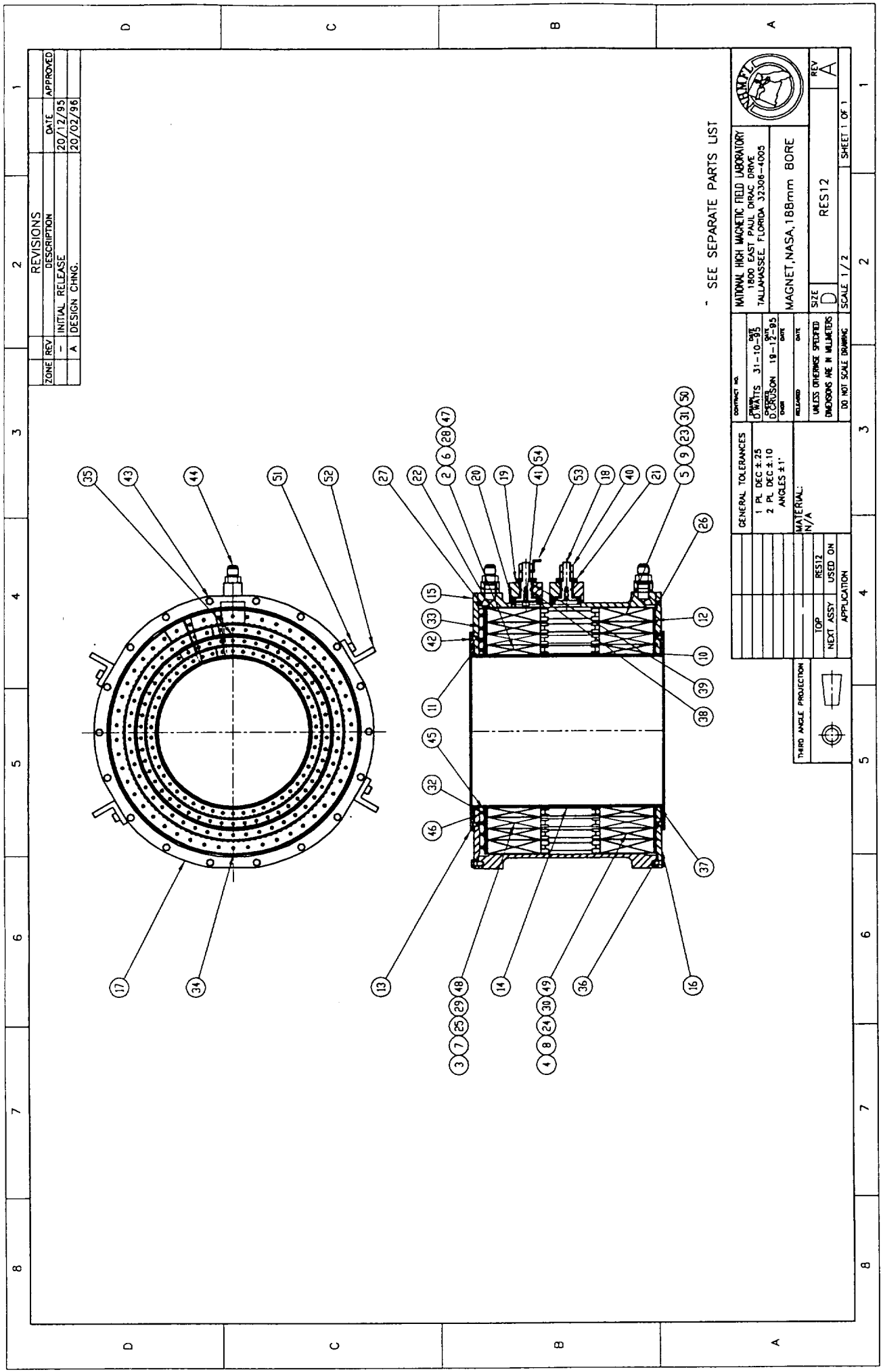
	3 kW
Required field:	3 gauss max.
Measured field:	2.3 gauss
Performed by:	Bird, Bole, Loffelbein

IXV. PACKAGING

The MDF-BC1 is adequately packaged for damage-free handling. After operation it was drained and dried by blowing compressed air through it for approximately 3 hours. It was then filled with Helium gas and closed.

CONCLUSIONS

The magnet project was successfully completed. Additional magnets could be built if requested. The primary change that could be made to attain higher field and/or uniformity would be to make the magnet longer. However, for this first magnet, the overall length was constrained in the contract to be less than or equal to 238.1 mm. The NHMFL looks forward to receiving results of the tests to be performed at NASA.

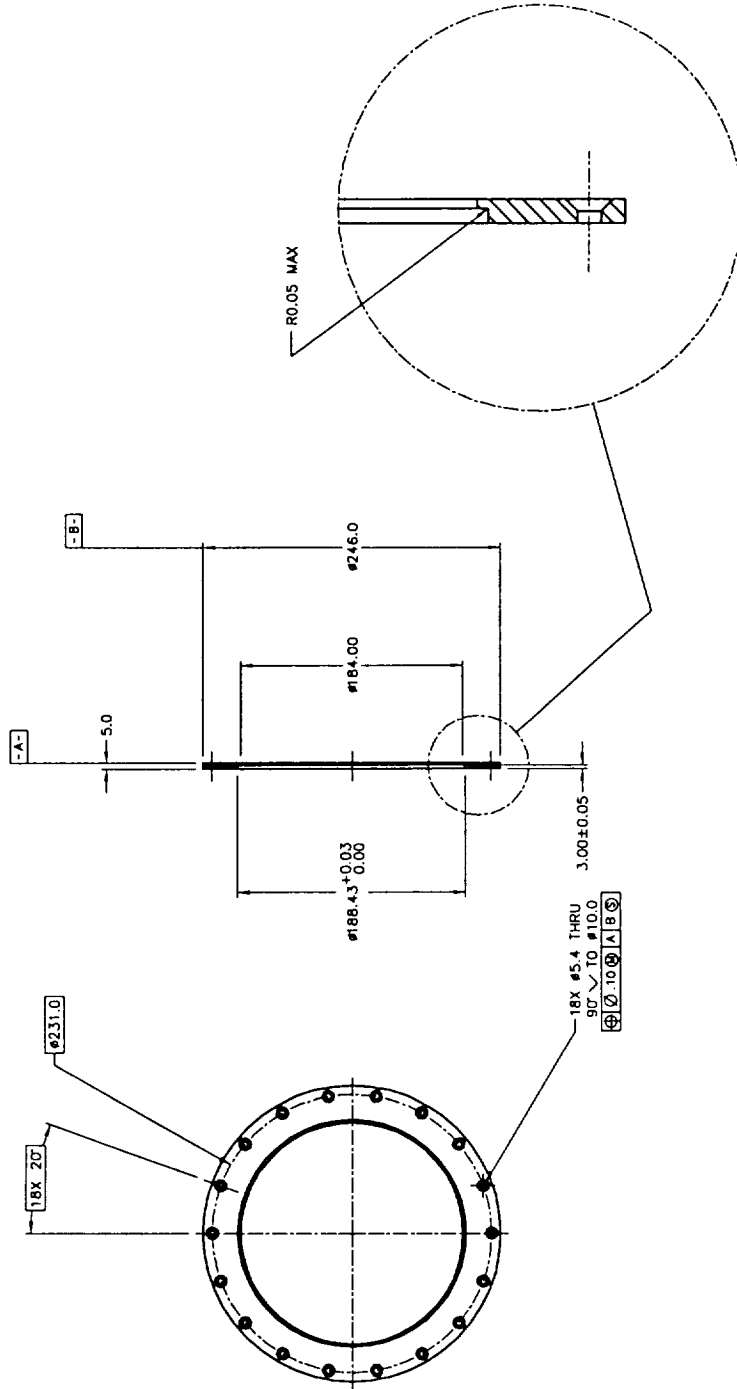


SEE SEPARATE PARTS LIST

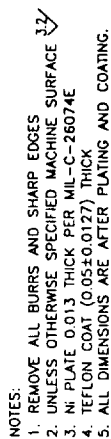
NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32306-4005	
MAGNET, NASA, 188mm BORE	
CONTRACT NO.	UNIV. OF FLA. 31-10-95
DATE	31-10-95
DESIGNED BY	D. GORDON
DATE	19-12-95
REVIEWED BY	
DATE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS	
DO NOT SCALE DRAWING	
SCALE 1/2	
REV A	
RES12	
SHEET 1 OF 1	




GENERAL TOLERANCES	
1 PL DEC ±.25	
2 PL DEC ±.10	
ANGLES ± 1°	
MATERIAL: N/A	
THIRD ANGLE PROJECTION	
TOP	RES12
NEXT ASSY	USED ON
APPLICATION	

- NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$
 3. NI PLATE (0.013) THICK PER MIL-C-26074E
 4. TEFLON COAT (0.05 \pm 0.0127) THICK
 5. ALL DIMENSIONS ARE AFTER PLATING AND COATING.



		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005		FLANGE, BORE TUBE	
GENERAL TOLERANCES 1 PL DEC \pm .25 2 PL DEC \pm .10 ANGLES \pm 1°		CONTRACT NO. D. WATTS 11/10/95		DATE 11/10/95	
MATERIAL 6061-T651 ALUMINUM ALLOY		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING		SCALE 1/1	
THIRD ANGLE PROJECTION 		TOP ASSY NASA		USED ON APPLICATION	
REVISIONS		ZONE REV		DATE	
- INITIAL RELEASE		-		27/12/95	
A CHANG'D NI AND TEFLON SPECS		A		26/06/96	
B MFG RELEASE		B		26/06/96	
APPROVED		DATE		REV	
1		2		B	

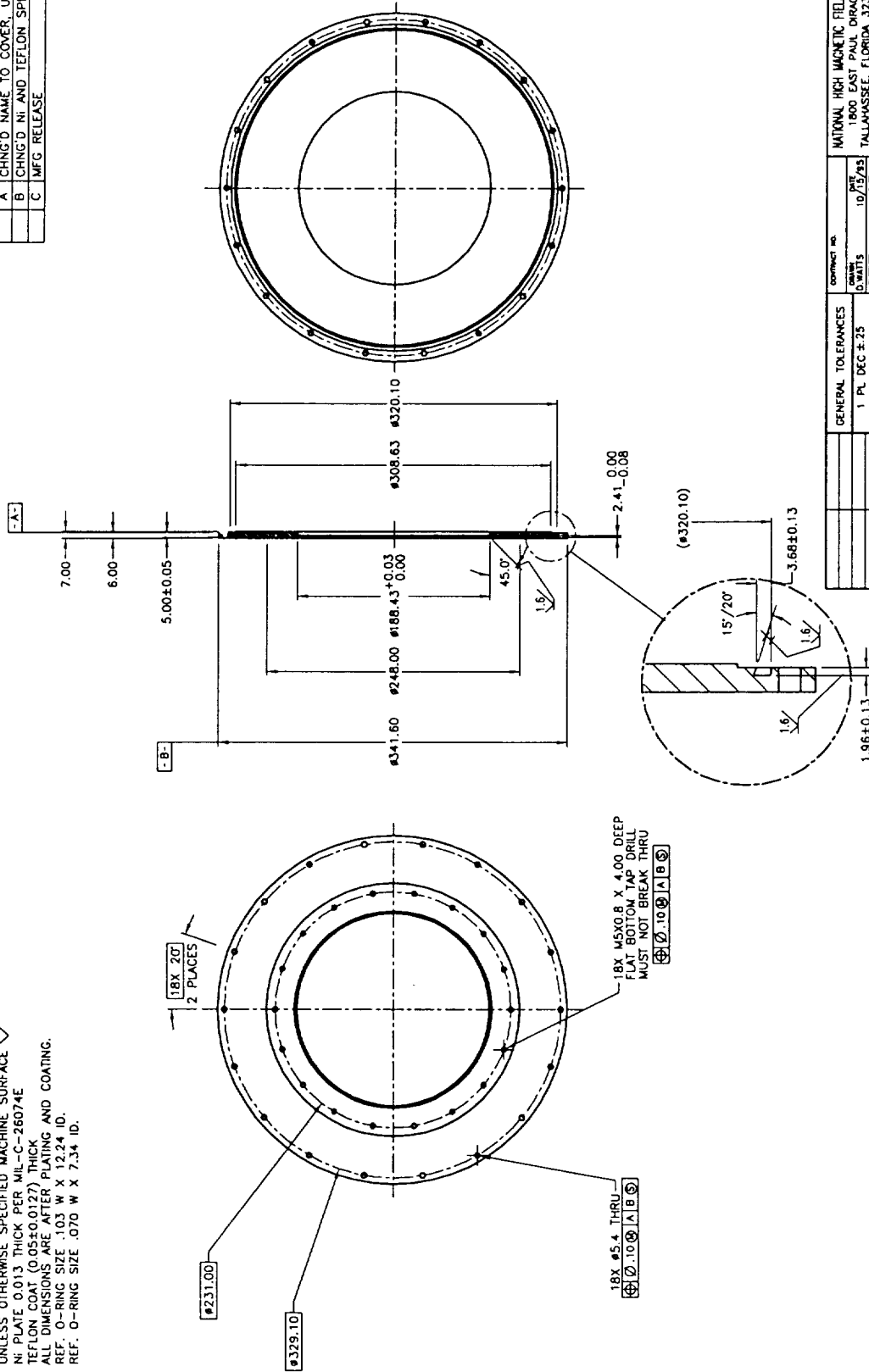


 THIRD ANGLE PROJECTION				GENERAL TOLERANCES 1 PL DEC \pm .25 2 PL DEC \pm .10 ANGLES \pm 1° MATERIAL: 6061-T651 ALUMINUM ALLOY		OFFPRINT NO. DATE D. C. DIVISION CHECKED DRAWN RELEASED		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005			
								BORE TUBE		SIZE D	
										RES/HOU - 12-02	
										REV B	
										SCALE 1/1 SHEET 1 OF 1	
										UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING	
										NEXT ASSY USED ON APPLICATION	

NOTES:

1. REMOVE ALL BURRS AND SHARP EDGES
2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$
3. NI PLATE 0.013 THICK PER MIL-C-26074E
4. TEFLON COAT (0.05 \pm 0.0127) THICK
5. ALL DIMENSIONS ARE AFTER PLATING AND COATING.
6. REF. O-RING SIZE .103 W X 12.24 ID.
7. REF. O-RING SIZE .070 W X 7.34 ID.

ZONE	REV	REVISIONS	DATE	APPROVED
-	INITIAL	RELEASE		
A	CHNG'D NAME TO COVER, UPPER		19/12/95	
B	CHNG'D NI AND TEFLON SPECS.		27/12/95	
C	MFG RELEASE		26/05/96	



		NATIONAL HIGH MAGNETIC FIELD LABORATORY 600 EAST PAUL DRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005	
CONTRACT NO. D. WATTS CHECKED DATE 10/15/95	GENERAL TOLERANCES 1. PL DEC \pm .25 2. PL DEC \pm .10 ANGLES \pm 1° MATERIAL: 1026 CRS	SIZE COVER, UPPER	REV RES/HOU-12-03A
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING	SCALE 1/1	SHEET 1 OF 1	1

- NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$
 3. NI PLATE 0.013 THICK PER MIL-C-26704E
 4. TEFLON COAT (0.005±0.0127) THICK
 5. ALL DIMENSIONS ARE AFTER PLATING AND COATING.
 6. REF. O-RING SIZE .103 W X 7.24 ID.
 7. REF. O-RING SIZE .070 W X 7.34 ID.

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	INITIAL RELEASE			
A	CHNG'D NI AND TEFLON SPECS.		27/12/93	
B	MFG RELEASE		26/06/96	
C	ADDED HOLES		10/09/96	

REVISIONS

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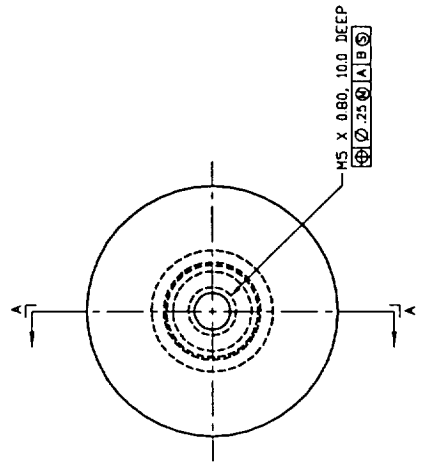
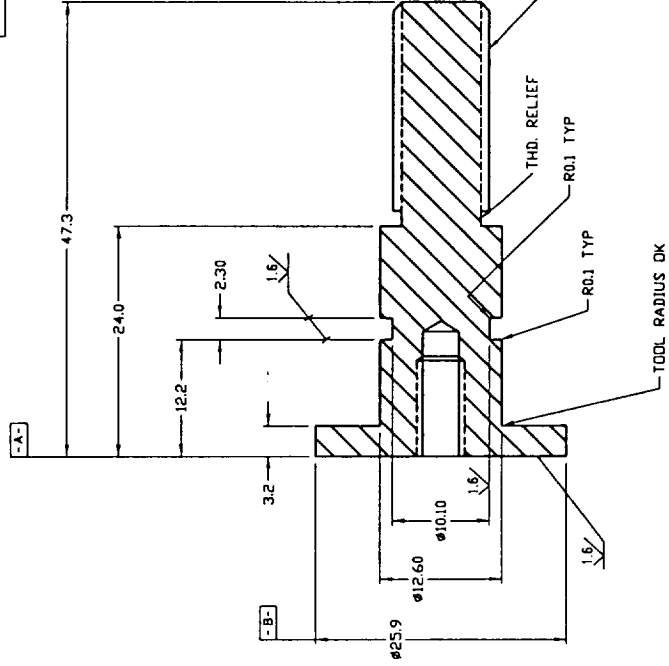
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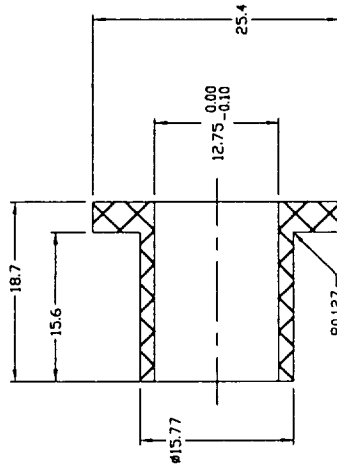
- NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{12}$
 3. ELECTROLESS NI PLATE 0.013 THICK PER MIL-C-26074E (10 - 12% PHOSPHORUS CONTENT), ALL OVER, INCLUDING TAPPED HOLE



ZONE	REV	REVISIONS	DATE	APPROVED
	-	INITIAL RELEASE		
	A	ADDED NI PLATING	11/12/93	
	B	CHG TO METRIC THDS	26/06/94	
	C	MFG RELEASE	26/06/95	
	D	M10X1.5 THD WAS M10X1.85 THD	08/08/96	

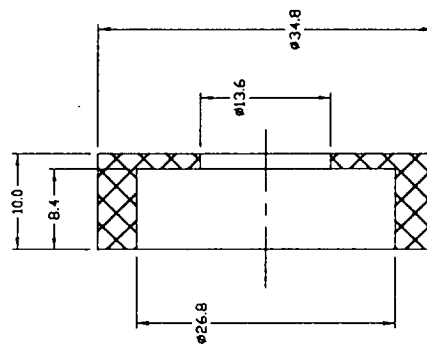


		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL ORRIS DRIVE TALLAHASSEE, FLORIDA 32308-1005	
CONTRACT NO. DRAWN: 10/18/95 CHECKED: DATE DATE		FEED-THROUGH	
GENERAL TOLERANCES 1. PL DEC $\pm .25$ 2. PL DEC $\pm .10$ ANGLES $\pm 1^\circ$		SIZE D RES/HOU - 12-05	
MATERIAL: C3600 - BRASS		SCALE 4/1	
THIRD ANGLE PROJECTION 		SHEET 1 OF 1	
NEXT ASSY APPLICATION		USED ON	

- NOTES:
 1. REMOVE ALL BURS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{}$



		MITRAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32306-4005		SLEEVE, INSULATOR		SIZE D		REV A	
CONTRACT NO. 0 CRUSON		DATE 10/19/95		DATE 10/19/95		DATE 10/19/95		DATE 10/19/95	
GENERAL TOLERANCES 1 PL DEC \pm .25 2 PL DEC \pm .10 ANGLES \pm 1°		MATERIAL: TEFLON		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS		DO NOT SCALE DRAWING		SCALE 4/1	
THIRD ANGLE PROJECTION 		NEXT ASSY APPLICATION		USED ON		SHEET 1 OF 1		SHEET 1 OF 1	






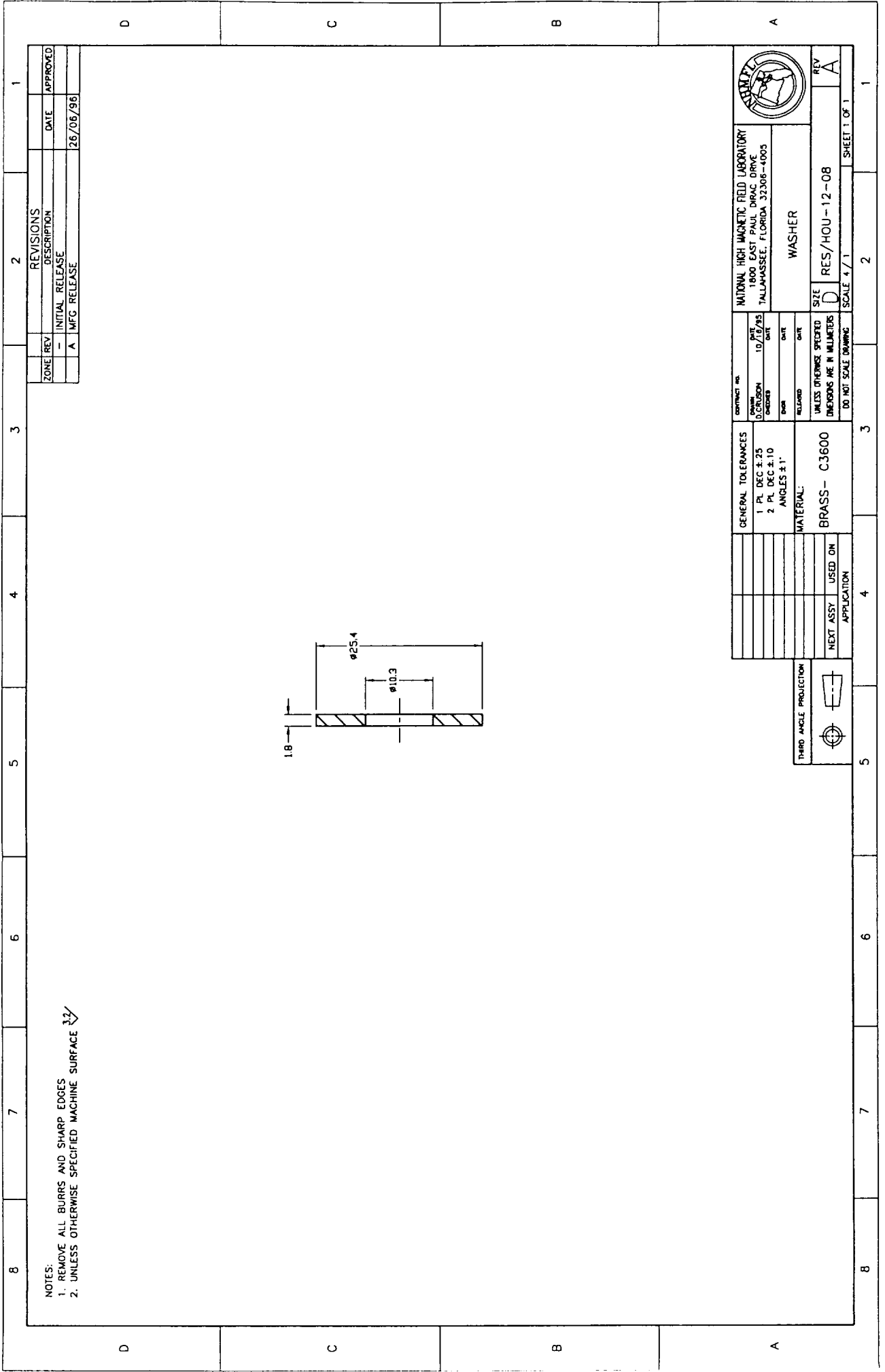
NOTES:

1. REMOVE ALL BURRS AND SHARP EDGES
2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE

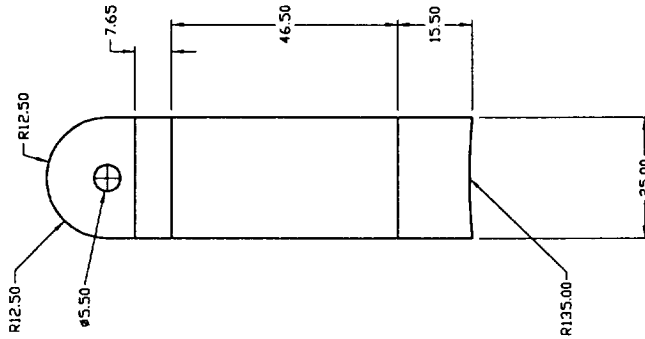
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		REVISIONS		
ZONE	REV	DESCRIPTION	DATE	APPROVED
	-	INITIAL RELEASE		
A	A	MFG RELEASE	26/06/98	

 THIRD ANGLE PROJECTION		GENERAL TOLERANCES 1 PL DEC $\pm .25$ 2 PL DEC $\pm .10$ ANGLES $\pm 1^\circ$		CONTRACT NO. DRAWN: D. CRIVELLO CHECKED: DATE: DATE: DATE: DATE: DATE: DATE:		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005		
		MATERIAL: TEFLON		SEAT, INSULATOR		SIZE: D RES/HOU-12-07	REV: A	
NEXT ASSY: USED ON: APPLICATION:		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS		DO NOT SCALE DRAWING		SCALE: 4/1		SHEET 1 OF 1



- NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$
 3. MATERIAL: Cu, 0.2 THICK
 4. ELECTROLESS Ni PLATE 0.013 MAX THICKNESS EACH SIDE PER MIL-C-26074E(10-12X PHOSPHORUS CONTENT)
 5. TEFLON COAT (0.05+-0.0127) THICK, MASK AS INDICATED



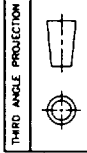
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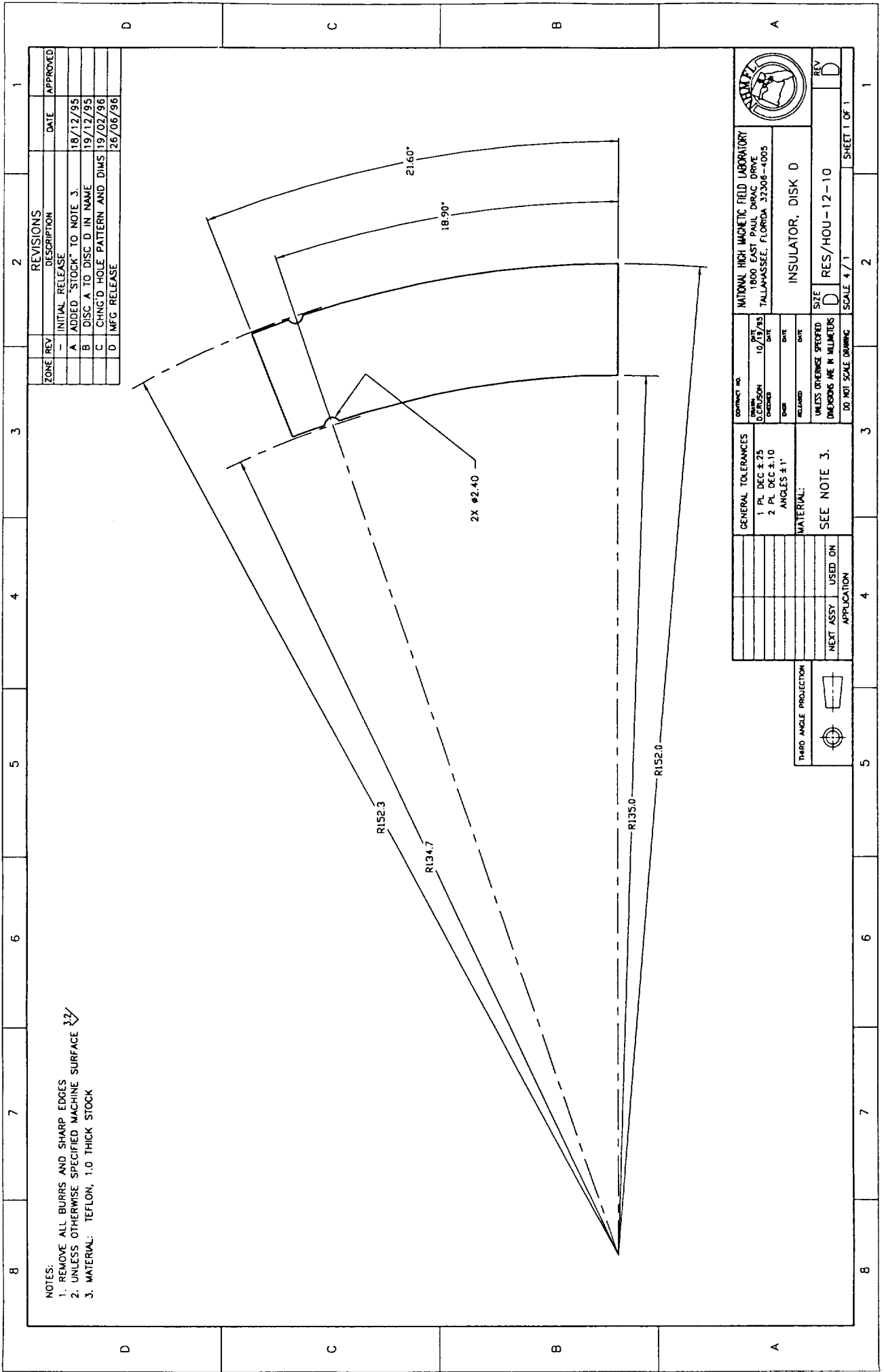
OMIT TEFLON COATING THIS FACE [5]

FLAT PATTERN

ZONE	REV	DESCRIPTION	DATE	APPROVED
	-	INITIAL RELEASE		
A		CHNG'D MATERIAL TO COPPER	18/12/95	
B		ADDED "COIL D" IN NAME	19/12/95	
C		CHNG'D DESIGN	07/03/97	

		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005	
CONTRACT NO.	DATE	REV	REV
10/23/95	10/23/95	D	C
1 PL DEC ± 25	2 PL DEC ± 10	SIZE	
ANGLES ± 1°		D	
MATERIAL:		SCALE 2/1	
SEE NOTE 3.		BUS BAR, COIL D	
UNLESS OTHERWISE SPECIFIED		RES/HOU-12-09	
DIMENSIONS ARE IN MILLIMETERS		SHEET 1 OF 1	
DO NOT SCALE DRAWING			





NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$
3. MATERIAL: TEFLON, 1.0 THICK STOCK

ZONE REV		REVISIONS		DATE		APPROVED	
		DESCRIPTION					
		INITIAL RELEASE					
A		ADDED "STOCK" TO NOTE 3.		18/12/95			
B		DISC A TO DISC D IN NAME		19/12/95			
C		CHNG D HOLE PATTERN AND DIMS		19/02/96			
D		MFG RELEASE		26/06/96			

GENERAL TOLERANCES		CONTRACT NO.		DATE		DATE		DATE		DATE	
1 PL DEC ±.25		DRAWN		10/19/95							
2 PL DEC ±.10		CHECKED									
ANGLES ±1°		DATE									
MATERIAL:		DATE									
SEE NOTE 3.		DATE									
UNLESS OTHERWISE SPECIFIED		DATE									
DIMENSIONS ARE IN MILLIMETERS		DATE									
DO NOT SCALE DRAWING		DATE									
SCALE 4/1		DATE									
SHEET 1 OF 1		DATE									



NATIONAL HIGH MAGNETIC FIELD LABORATORY
1800 EAST PAUL DIRAC DRIVE
TALLAHASSEE, FLORIDA 32308-4005

INSULATOR, DISK D

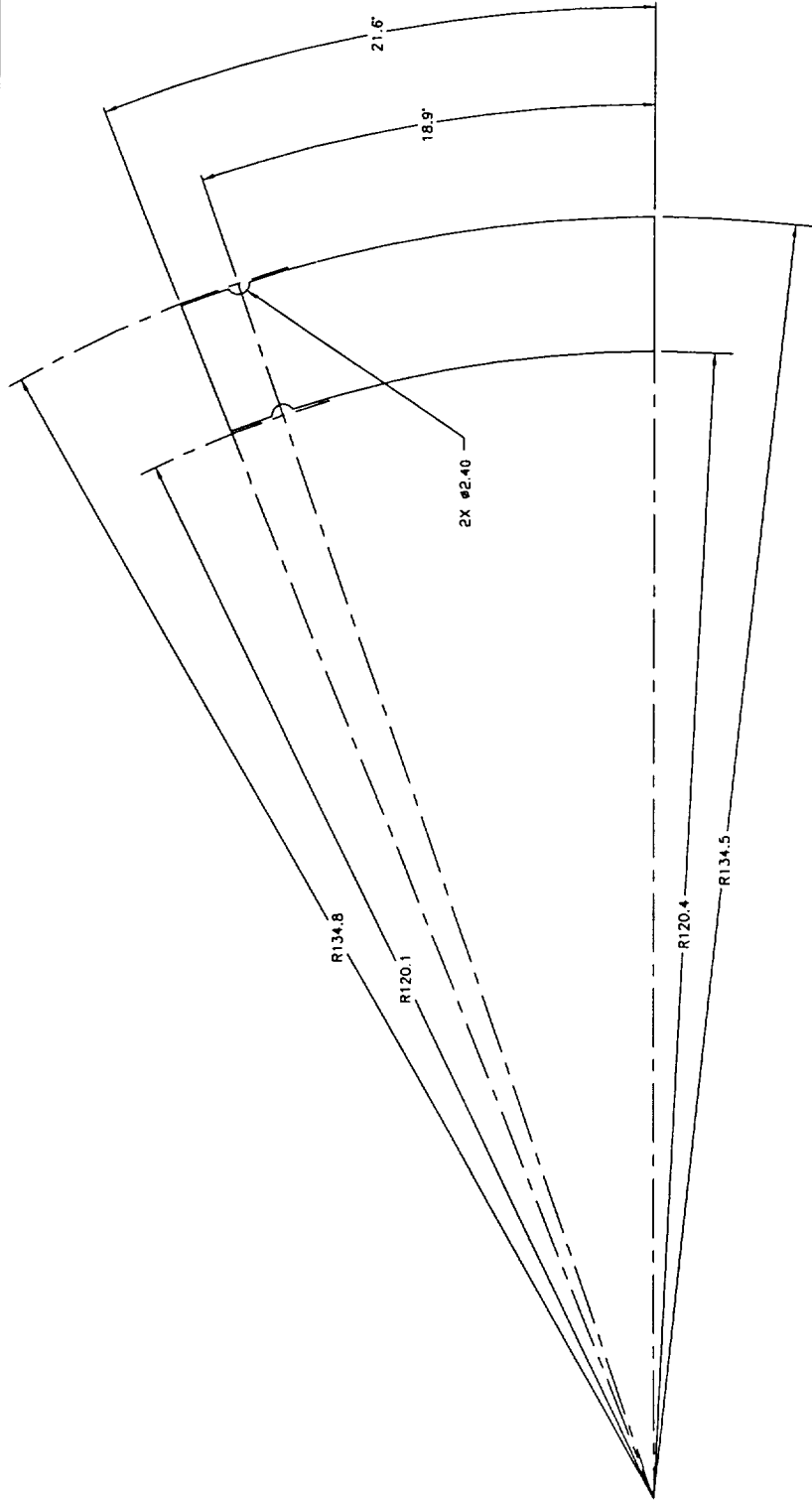
SIZE D
RES/HOU-12-10

REVISIONS
REV D



THIRD ANGLE PROJECTION

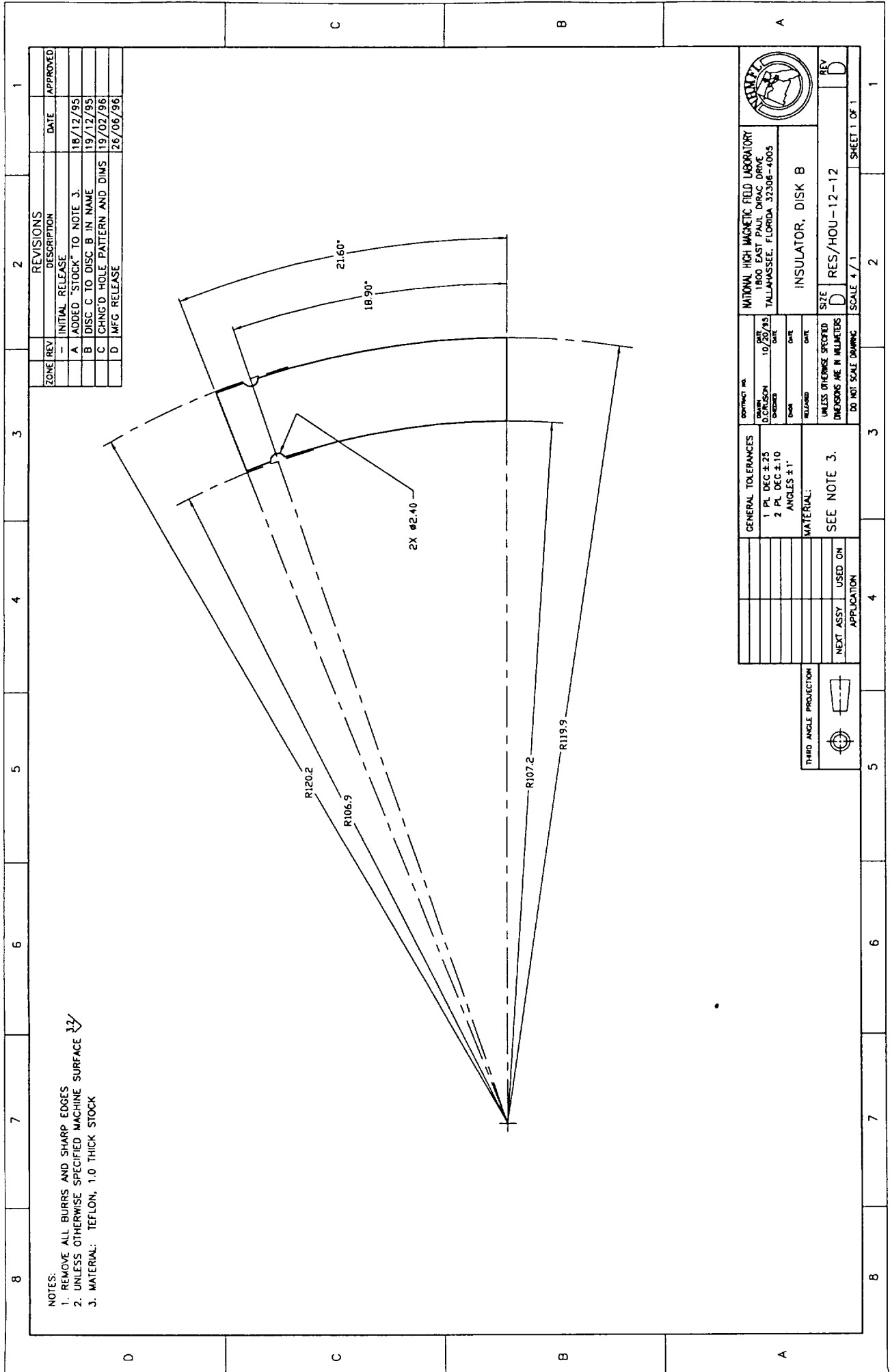
NEXT ASSY USED ON APPLICATION

- NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$
 3. MATERIAL: TEFLON, 1.0 THICK STOCK

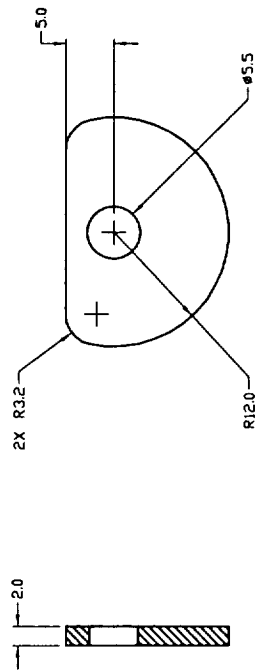


ZONE	REV	DESCRIPTION	DATE	APPROVED
	-	INITIAL RELEASE		
	A	ADDED "STOCK" TO NOTE 3.	18/12/95	
	B	DISC B TO DISC C IN NAME	19/12/95	
	C	CHNG D HOLE PATTERN AND DIMS	19/02/96	
	D	MFG RELEASE	26/06/96	



		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32306-4005	
CONTRACT NO. DRAWN CHECKED ENGINEER RELEASED		DATE 10/20/95 DATE DATE DATE	
GENERAL TOLERANCES 1 PL DEC ± .25 2 PL DEC ± .10 ANGLES ± 1°		MATERIAL: SEE NOTE 3.	
THREADED ANGLE PROJECTION 		NEXT ASSY. USED ON APPLICATION	
SIZE D RES/HOU-12-11		SCALE 4/1	
SHEET 1 OF 1		REV D	



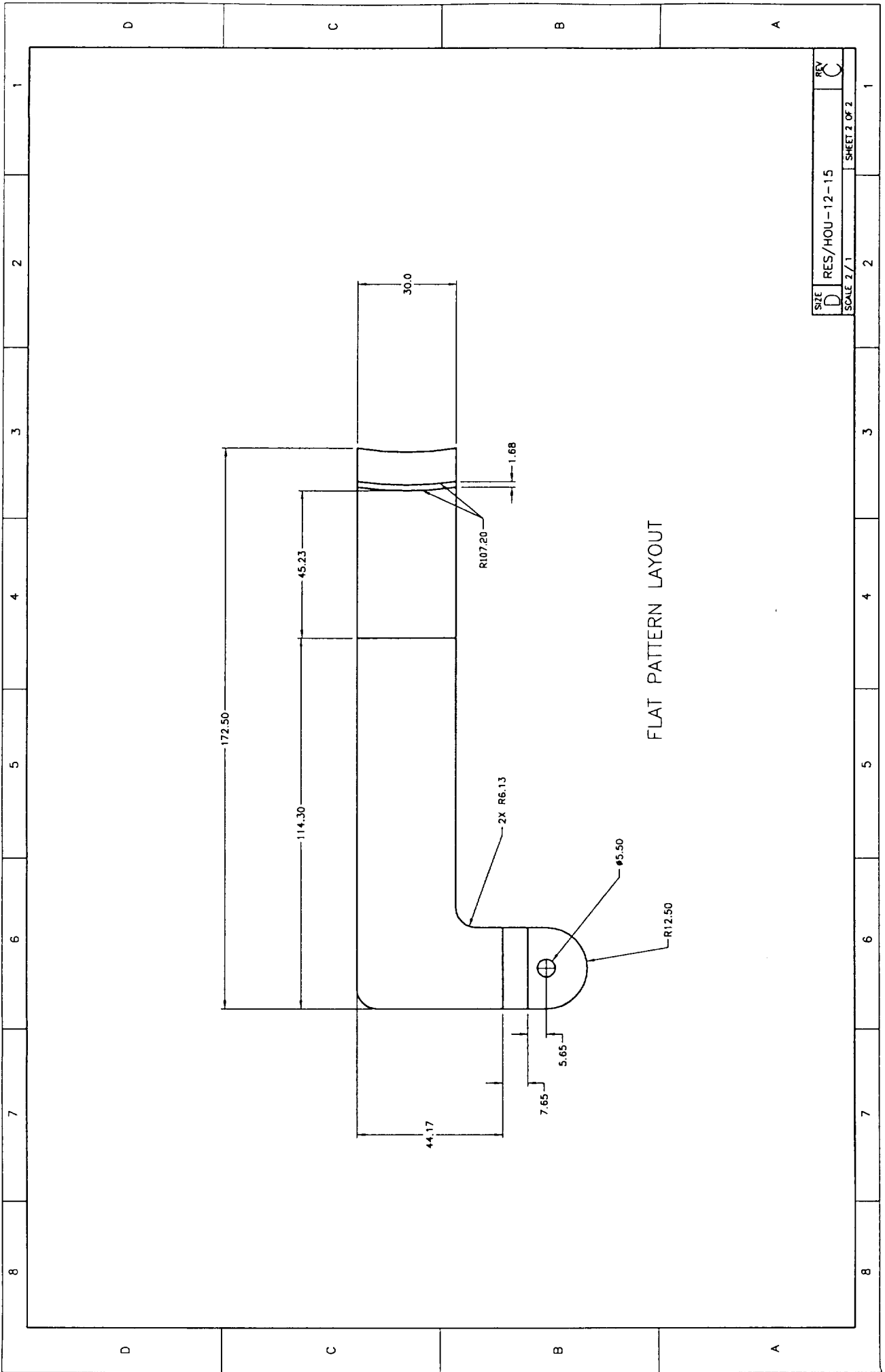
NOTES:
 1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{}$



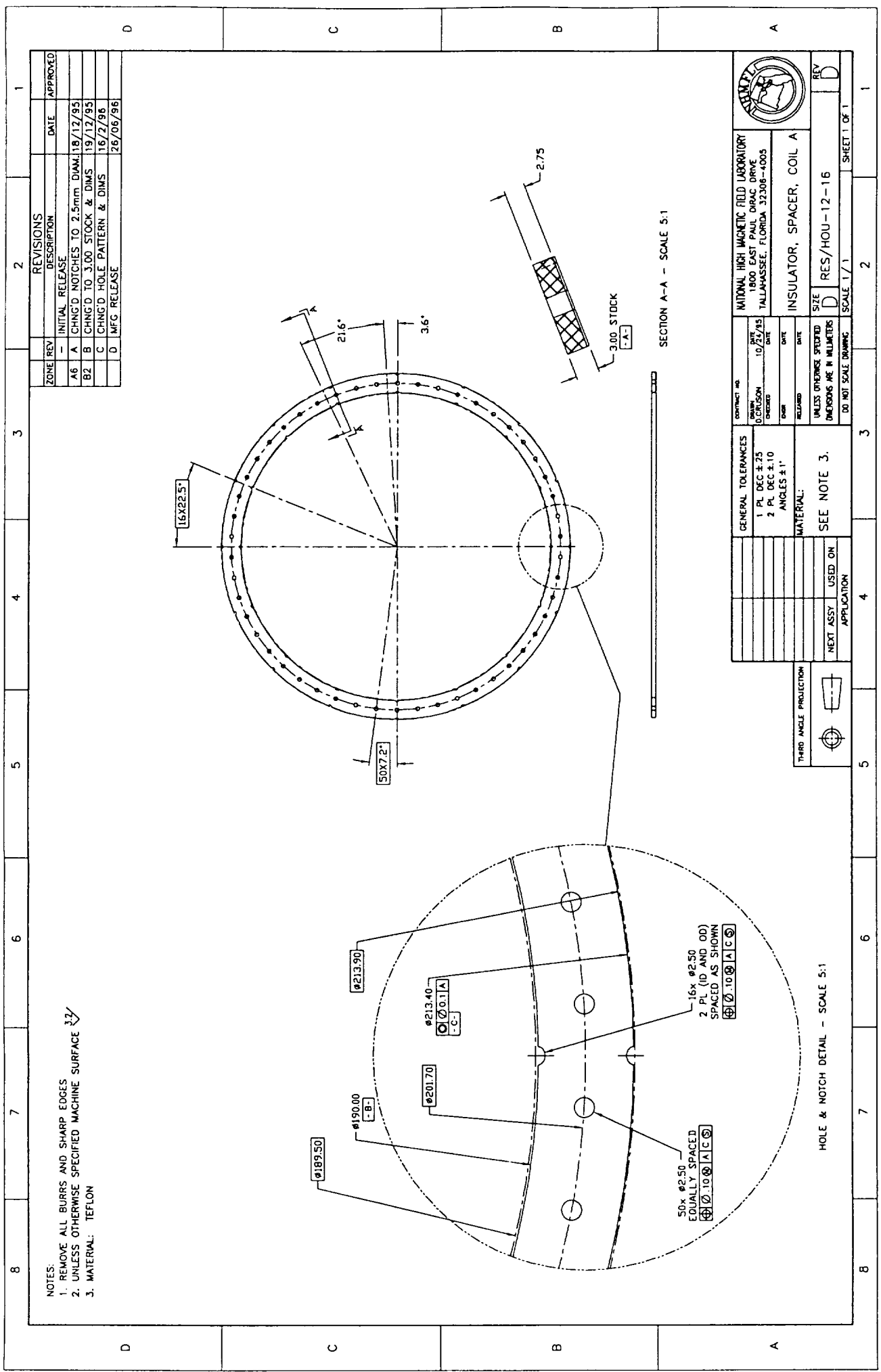
ZONE	REV	DESCRIPTION	DATE	APPROVED
-	-	INITIAL RELEASE		
A	A	MFG RELEASE	26/06/96	

		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005	
CONTRACT NO. DRAWN DATE 11/2/95 CHECKED DATE RELEASED DATE		WASHER, BUSSING SIZE D RES/HOU-12-13 SCALE 4/1	
GENERAL TOLERANCES 1 PL DEC ±.25 2 PL DEC ±.10 ANGLES ±1° MATERIAL: 304 SS		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING	
THIRD ANGLE PROJECTION 		NEXT ASSY USED ON APPLICATION	

8	7	6	5	4	3	2	1
D	C	B	A				



SIZE	REV
D	C
RES/HOU-12-15	
SCALE 2/1	
SHEET 2 OF 2	



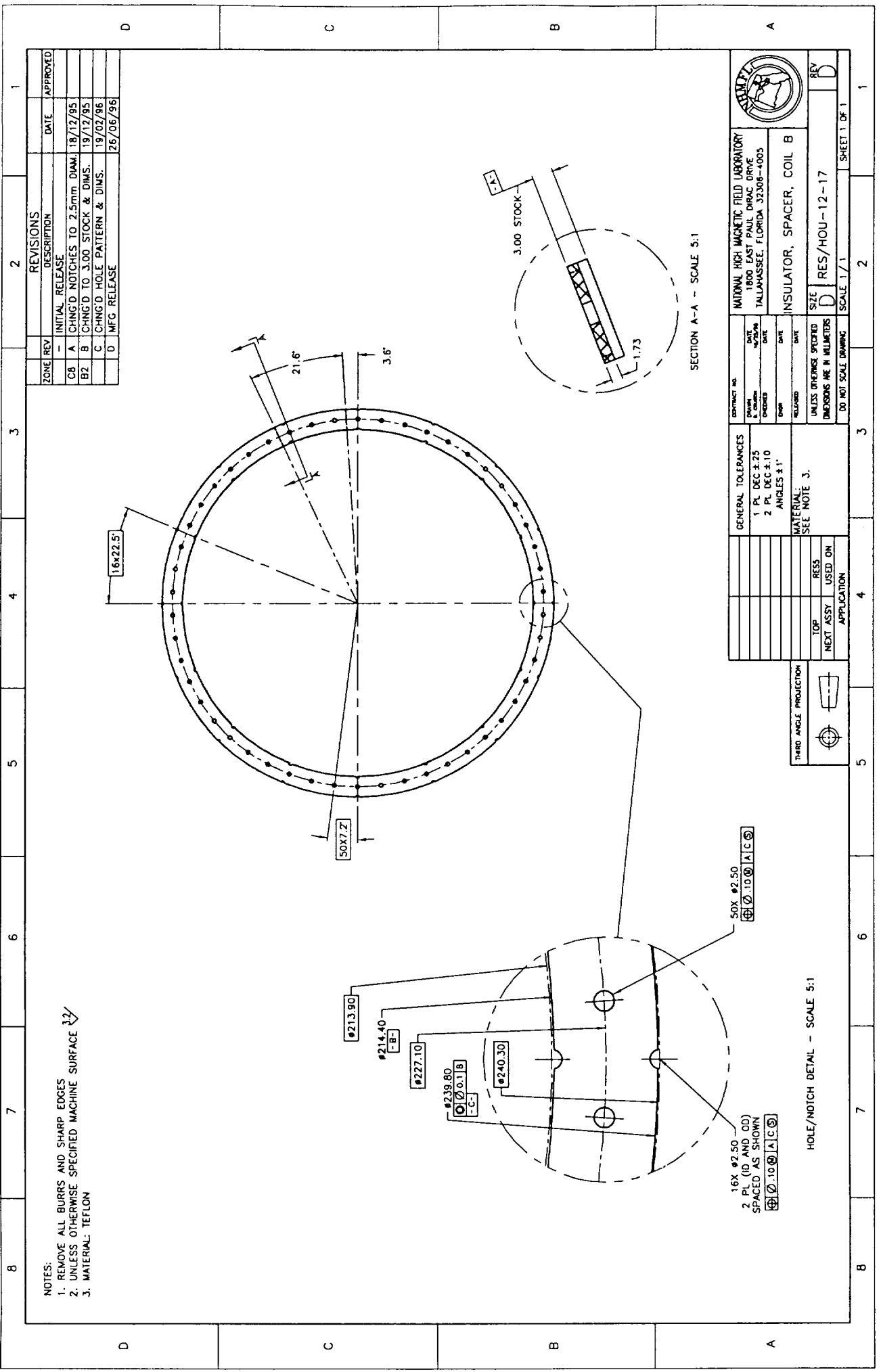
NOTES:
 1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$
 3. MATERIAL: TEFLON

ZONE	REV	DESCRIPTION	DATE	APPROVED
A6	A	CHNG'D NOTCHES TO 2.5mm DIA	18/12/95	
B2	B	CHNG'D TO 3.00 STOCK & DIMS	19/12/95	
C	C	CHNG'D HOLE PATTERN & DIMS	16/2/96	
D	D	MFG RELEASE	26/06/96	

		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005	
CONTRACT NO. ORDER NO. QUANTITY DATE	10/24/95 10/24/95 10/24/95 10/24/95	GENERAL TOLERANCES 1 PL DEC ±.25 2 PL DEC ±.10 ANGLES ±1°	MATERIAL: SEE NOTE 3.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING	SIZE D RES/HOU-12-16	INSULATOR, SPACER, COIL A	REV D

HOLE & NOTCH DETAIL - SCALE 5:1

SECTION A-A - SCALE 5:1

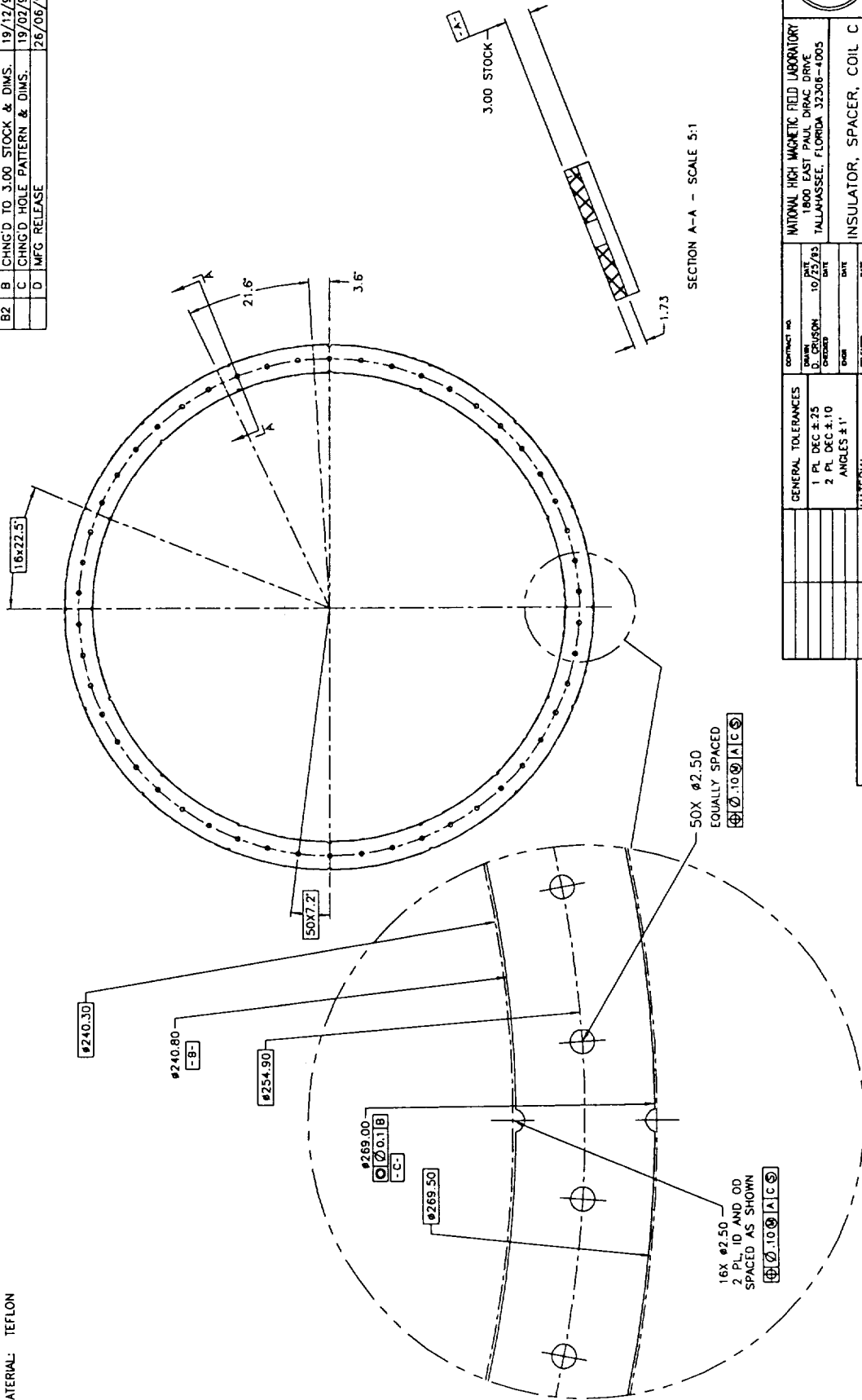


NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{16}$
3. MATERIAL: TEFLON

REVISIONS		DATE		APPROVED	
ZONE	REV	DESCRIPTION		DATE	
08	A	INITIAL RELEASE		18/12/95	
B2	B	CHNG'D NOTCHES TO 2.5mm DIAM.		19/12/95	
C	C	CHNG'D TO 3.00 STOCK & DIMS.		19/02/96	
D	D	MFG RELEASE		26/06/96	

CONTRACT NO.		NATIONAL HIGH MAGNETIC FIELD LABORATORY	
DATE		1800 EAST PAUL DRAC DRIVE	
DATE		TALLAHASSEE, FLORIDA 32306-4005	
DATE		INSULATOR, SPACER, COIL B	
DATE		UNLESS OTHERWISE SPECIFIED	
DATE		DIMENSIONS ARE IN MILLIMETERS	
DATE		SCALE 1/1	
DATE		SHEET 1 OF 1	
DATE		REV	
DATE		RES/HOU-12-17	

- NOTES:
 1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE 12/
 3. MATERIAL: TEFLON



SECTION A-A - SCALE 5:1

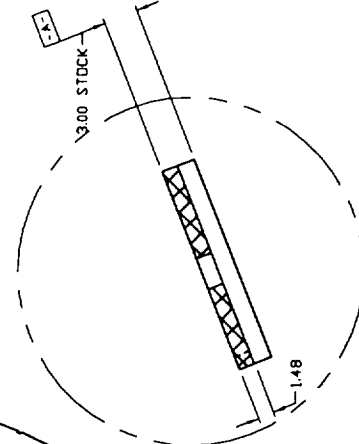
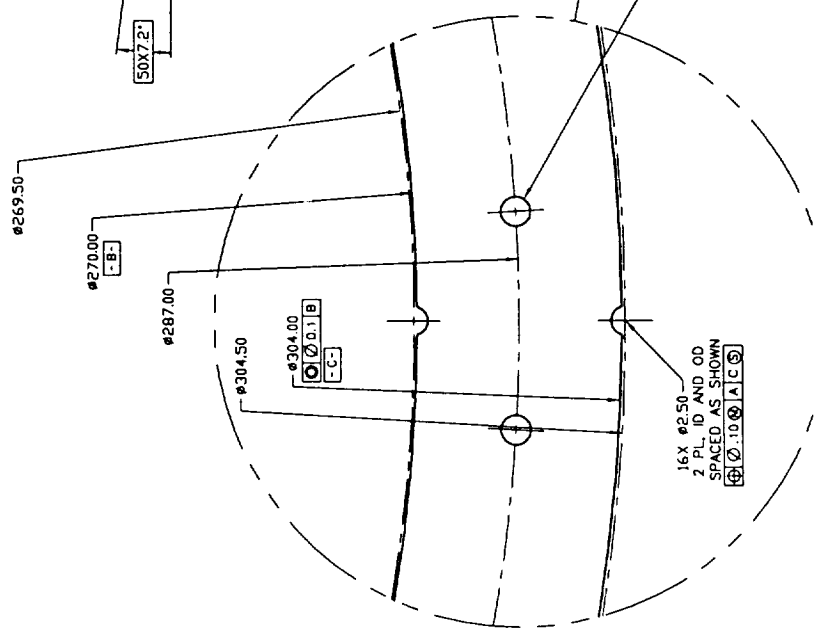
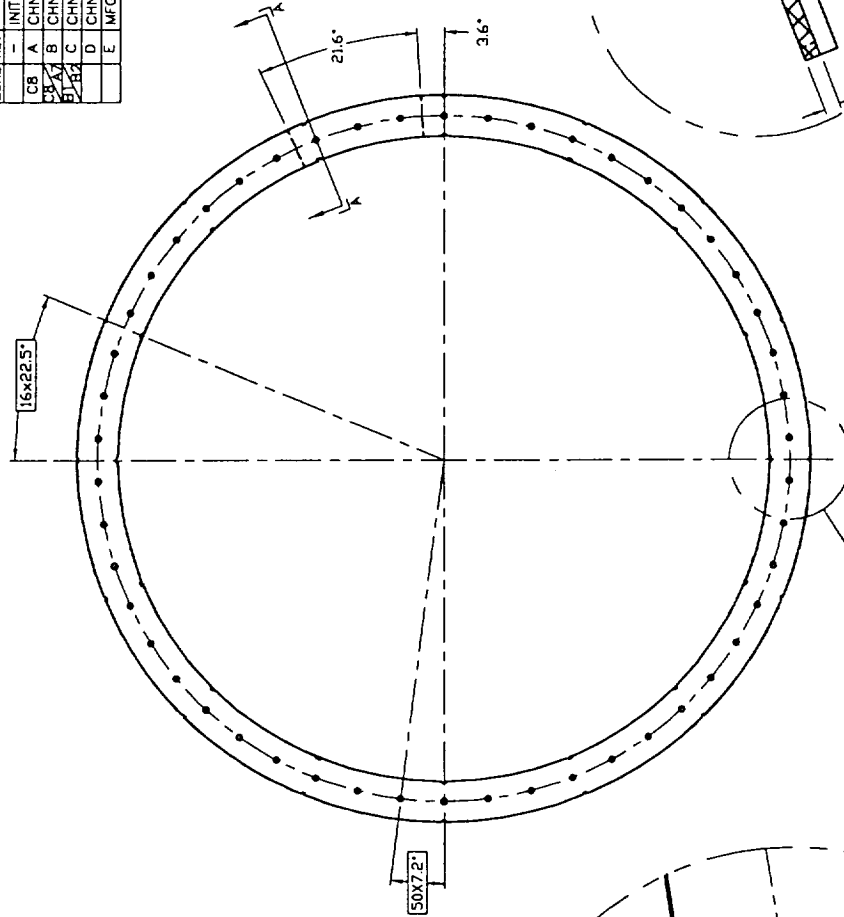
HOLE/NOTCH DETAIL - SCALE 5:1

		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005	
CONTRACT NO. DRAWING NO. REVISION DATE	PART NO. DATE DATE DATE	GENERAL TOLERANCES 1 PL DEC ±.25 2 PL DEC ±.10 ANGLES ± 1° MATERIAL: SEE NOTE 3.	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING
TOP ANGLE PROJECTION 		TOP NEXT ASSY. USED ON APPLICATION	SIZE RES/HOU-12-18 SCALE 1/1 SHEET 1 OF 1

ZONE REV DESCRIPTION DATE APPROVED	INITIAL RELEASE CHNG'D NOTCHES TO 2.5mm DIAM. CHNG'D TO 3.00 STOCK & DIMS. CHNG'D HOLE PATTERN & DIMS. MFG RELEASE	18/12/95 19/12/95 19/02/96 26/06/96
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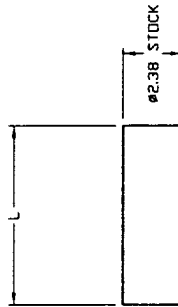
- NOTES:
 1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE \sqrt{R}
 3. MATERIAL: TEFLON

ZONE	REV	DESCRIPTION	DATE	APPROVED
CB	A	INITIAL RELEASE	00/MM/YY	
CB	B	CHNG'D NOTCHES TO 2.5mm DIAM.	18/12/95	
CB	C	CHNG'D AND ADDED DIMS.	18/12/95	
CB	D	CHNG'D TO 3.00 STOCK & DIMS	19/12/95	
CB	E	CHNG'D HOLE PATTERN & DIMS	19/02/96	
CB	F	MFG RELEASE	26/06/96	



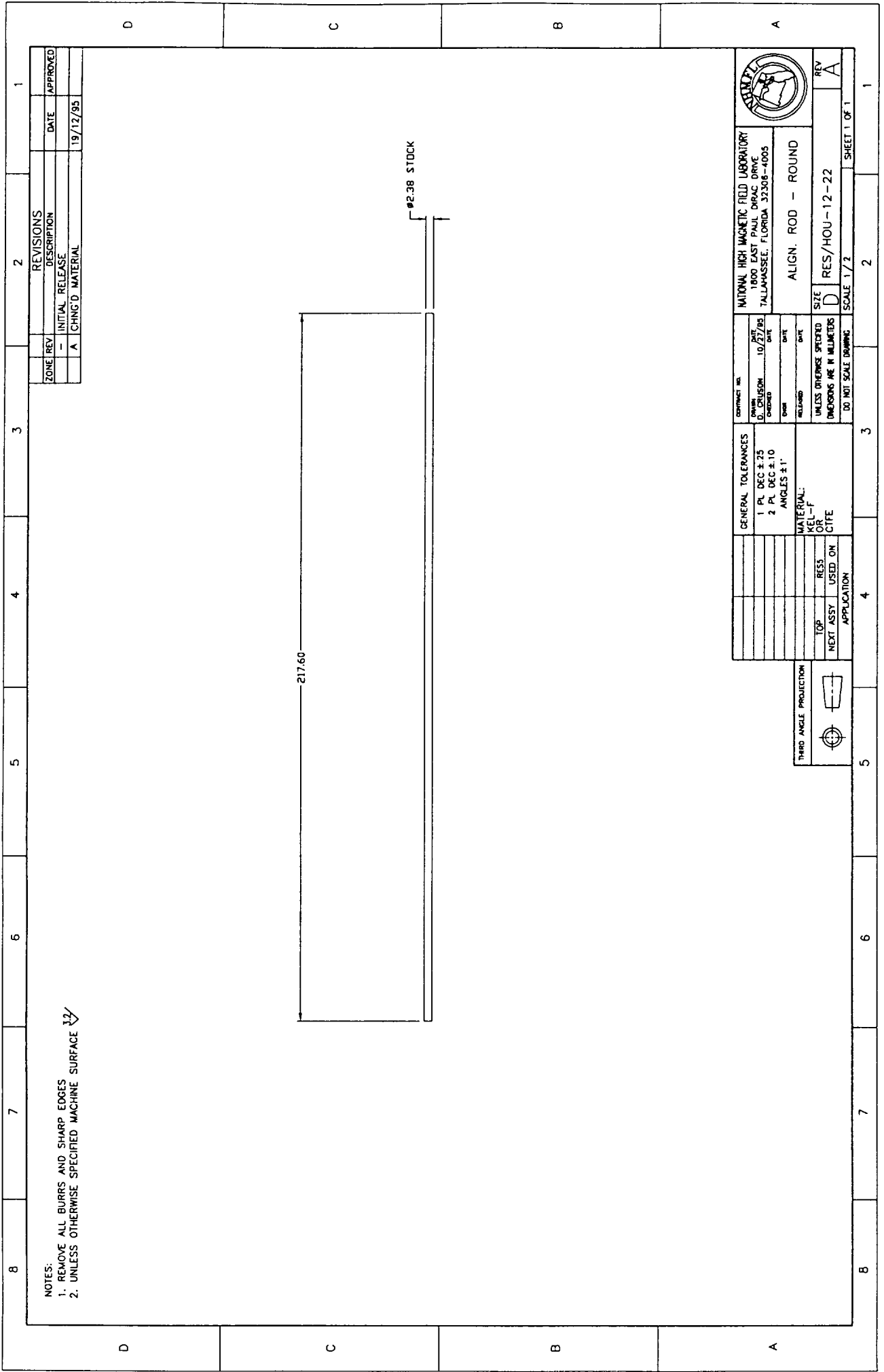
		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005	
CONTRACT NO. DIVISION PROJECT NO. DATE	DATE 10/17/95 DATE	COIL D DATE DATE	REV E
GENERAL TOLERANCES 1 PL DEC $\pm .25$ 2 PL DEC $\pm .10$ ANGLES $\pm 1^\circ$		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING	
MATERIAL: SEE NOTE 3.		SIZE D	
TOP NEXT ASSY USED ON APPLICATION		SCALE 1/1 SHEET 1 OF 1	

NOTES:
 1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{\text{ }}$

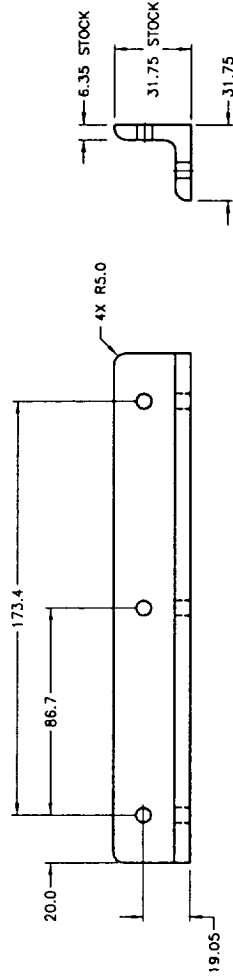
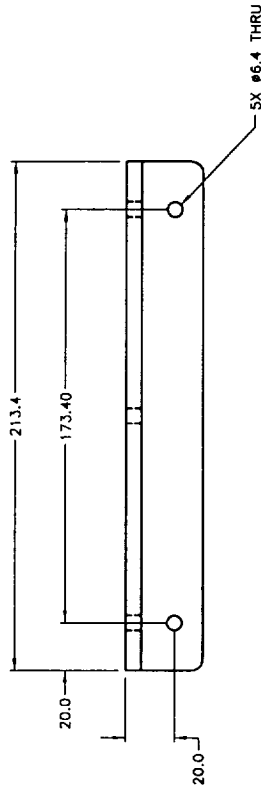




TAB	L	QTY.
01	7.57	1.01
02	6.00	8

		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4003	
CONTRACT NO. DRAWN D. CRUMSON CHECKED DATE 10/27/85		PLUG, RETAINER, SPRING SIZE D RES/HOU-12-20	
GENERAL TOLERANCES 1 PL DEC $\pm .25$ 2 PL DEC $\pm .10$ ANGLES $\pm 1^\circ$		MATERIAL: KEL-F UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING	
THIRD ANGLE PROJECTION 		APPLICATION TOP NEXT ASSY USED ON CITE	
REVISIONS ZONE REV - A CHNG'D MATERIAL		DATE 19/12/05	
APPROVED 		REV A	



NOTES:
 1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{32}$



		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005		ATTACHMENT BRACKET		REV —	
CONTRACT NO. DRAWING		DATE DATE DATE DATE		SIZE D		RES/HOU-12-23	
GENERAL TOLERANCES 1 PL DEC ±.25 2 PL DEC ±.10 ANGLES ±1°		MATERIAL: 304SS		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS		SCALE 1/1	
THIRD ANGLE PROJECTION 		NEXT ASSY USED ON APPLICATION		SHEET 1 OF 1		1	

- NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\frac{1}{2}$
 3. MATERIAL: C10100, C10200 OR C11000, HALF HARD
 4. ELECTROLESS NI PLATE 0.013 MAX THICKNESS EACH SIDE PER MIL-C-26074E(10-12% PHOSPHORUS CONTENT)

20 -B-

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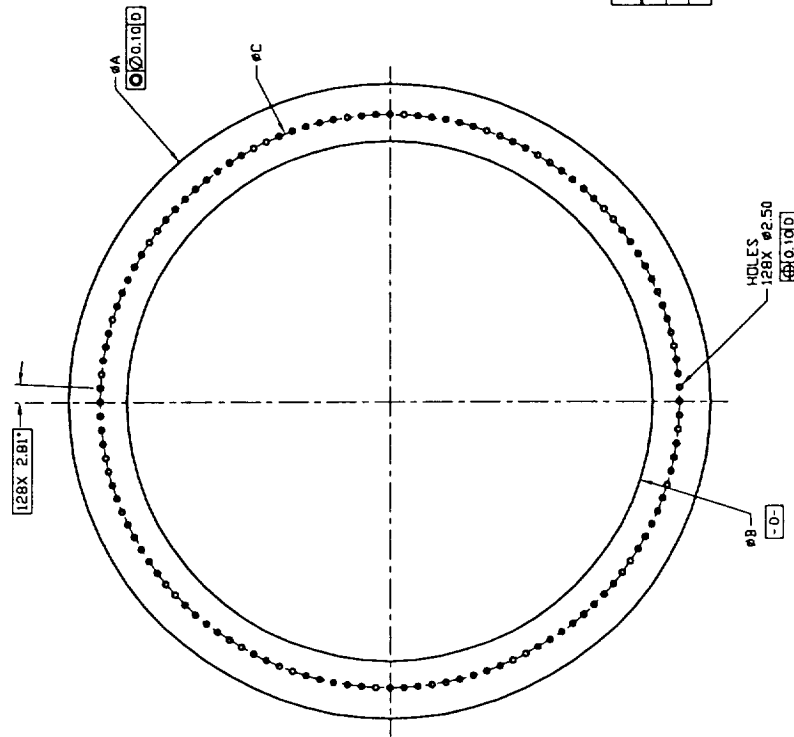
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10X R1.25

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10X R1.25

- NOTES:
1. REMOVE ALL BURRS AND SHARP EDGES
 2. UNLESS OTHERWISE SPECIFIED MACHINE SURFACE $\sqrt{10}$
 3. MATERIAL: C10100, C10200, OR C11000, 0.2 THICK, HALF HARD
 4. ELECTROLESS NI PLATE 0.013 THICK PER MIL-C-26074E (10 - 12% PHOSPHORUS CONTENT)
 5. ϕ - BOLT CIRCLE DIAMETER
? - COOLING HOLE ANGLE



TABULATE	ϕA	ϕB	ϕC
1	236.0	192.0	213.90
2	266.0	218.0	240.30
3	302.0	244.0	269.50

ALL B.C. DIAMETERS ARE BASIC
SEE NOTE 5

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	-	INITIAL RELEASE		
A		CHNG'D NI PLATING SPEC.	14/12/95	
B		ADDED 2.5 HOLES & CHNG'D DIMS	18/12/95	
C		CHNG'D TAB ORDER	19/12/95	
D		CHNG'D MATERIAL AND NI PLATE	27/12/95	
E		MFG RELEASE	26/06/96	
F		128 HOLES WAS 120 HOLES	07/08/96	

		NATIONAL HIGH MAGNETIC FIELD LABORATORY 1800 EAST PAUL DIRAC DRIVE TALLAHASSEE, FLORIDA 32308-4005	
CONTRACT NO. DATE CHECKED DATE	10/10/95 DATE	BUSSING	
GENERAL TOLERANCES 1 PL DEC $\pm .25$ 2 PL DEC $\pm .10$ ANGLES $\pm 1^\circ$		MATERIAL: SEE NOTE 3	
THIRD ANGLE PROJECTION 		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING	
NEXT ASSY APPLICATION		SIZE RES/MAG-12-04	
SCALE 1/1		SHEET 1 OF 1	

